present our drug laboratory is amply equipped for chemical investigation, but the very necessary equipment for physiological assay is still wanting. Until we do have this installed we are helpless to give conclusive information in regard to the relative values of the drugs I have mentioned, and many others.

THE MANUFACTURE OF ENAMELED WARE.

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THE manufacture of enameled-steel cooking utensils is an industry which could and should be carried on in Kansas. Her natural resources (especially her minerals and abundant supply of fuel), her industries allied to enamel making, and her central location, are all points in favor of Kansas as compared with other states for the location of enameling works.

An enamel is a vitreous silicate resembling glass or porcelain, but which forms an intimate coating on the surface of a metal. On a vessel which is to be used for cooking the enamel must not be brittle and must have a coefficient of expansion near that of the metal. It must resist both acids and alkalies and must contain no lead or other poisonous materials.

The following materials are used in the making of enamel for cooking utensils: Flint, quartz and glass-sand supply the silica, feldspar and clay the alumina. Fluorspar and cryolite are added on account of their fluorin content and assist in making the enamel opaque, thus giving it "body." Soda-ash and pearl-ash are fluxes, and borax, which acts as a flux also, keeps the enamel from being brittle and brings out the color from the metallic oxids used as pigments. Saltpeter and Chili saltpeter act as decolorizers, as well as being fluxes; and magnesium sulfate and ammonium carbonate, which are added to thicken the wet enamel, are among the raw materials, as well as carbon, chromium oxid, cobalt oxid, copper oxid, uranium oxid, selenium and gold oxid, and especially tin oxid, antimony oxid and zinc oxid, which are pigments giving color to the enamel.

Enameling is still held as a secret art, and the formulas are carefully guarded. In the company with which I was chemist for three years very few visitors are allowed to go through the works, and none of these are taken through the laboratory or the room in which the enamels are mixed. Each of the raw materials used has a number, and they are always designated as such. They are shipped so that the bill of lading contains only the number. All

boxes, barrels and bags have these numbers on them, and they are stored in bins under their numbers.

Employees of one department are never allowed in another, and after a man has worked in one department he is barred from all others. Then, too, some of the enamels are made up of several different frits, melted at different times, and mixed by different men.

In the making of an enamel the various raw materials are loaded from their respective bins into small cars called "dollies." These are filled to a line which approximates the correct weight, then they are pulled on a scale, the beam of which is hidden from the workman, and the chemist in charge indicates whether the load is light or heavy, and the workmen correct this by shoveling on more or taking some off. When each of the "dollies" is corrected so that the required amount of material for a mix is in it, all are dumped on a large hard maple floor, the coarser material on the bottom and the finer on the top. This pile is thoroughly mixed by shoveling, and is loaded into an electric elevator which hoists it to its bin. There is a bin for each different kind of an enamel, and a traveling bucket which holds a melt (about 1200 pounds) carries the mixing to the crucible furnaces where it is melted into a liquid glass.

These crucible furnaces are regenerative reverberatory furnaces like those used in the manufacture of glass, and our natural gas or crude oil would be an ideal fuel for them. However, in the older enameling works coal is used, and in the later ones, mainly in the coal-fields, producer-gas is used as a fuel. The temperature required for the different enamels runs from 1000° C. for a glaze to 1300° C. for a ground coat, and the temperatures are measured by a pyrometer, using a Herans platinum iridium thermo-couple. Natural gas or crude oil as fuel would make the attaining and regulation of these temperatures an easy matter. Each furnace will give seven or eight melts a day, and is in charge of a head melter. After the enamel is melted into a liquid glass a fire-clay plug in the front of the furnace is pulled out and the molten enamel is allowed to flow into a large tank of cold water. The contact with this causes it to quench into very small particles. The water is drained from the tanks and the "enamel frit" is left. This is shoveled into pans (a certain weight to a pan) and is ready for grinding.

In the mill-room the enamel frit is ground in large ball mills for about thirty hours. These mills are cylindrical, about eight feet long and five feet in diameter, and are lined with porcelain bricks. The frit is put into them with an equal amount of water and several

per cent. of white imported clay. For the white cover enamels tin oxid is also put in at this time. The enamel is ground until it will pass through a hundred-mesh sieve, by large round flint stones which are put in with the mixture. The enamel, on being taken from the mill, has about the consistency of rich cream. This is loaded into tanks, where it is allowed to age a week or so.

From the mill-room the enamel is taken to the dipping-room, where it is put into tanks that are like large dish-pans. These are sunk into tables, and at each tank a "dipping girl" works. The dipping girl takes the stamped-out steel vessel, which has been thoroughly cleaned, and plunges it into the enamel. When taken out the wet enamel forms a thin film all over it. By a gentle swinging motion the excess of enamel is thrown off, and the vessel is placed bottom down on three metal points projecting from a board. Three or four vessels are put on a board and then carried to the drying-room, a room which is between the dipping- and furnace-rooms.

The furnace-room contains a long bank of muffle-furnaces, each one of which has a muffle about twelve feet by six. In these the ware is put after drying. The temperature in these furnaces is about 1100° C., and here the little powdered particles of enamel are fused together in a solid glass covering over the vessel. About five minutes' time is required for each load put into the furnace. Five men and boys attended each furnace—the head burner and two assistants, two carrier boys, and a beading boy. The beading boy takes up a little black enamel (an enamel made as above described) on his finger and puts it around the top of the vessel before it is burned. This makes the black bead around the top of the vessel.

Each coat is burned separately. For instance, we have a tea-kettle that is to be a three coat—white inside, turquois-blue mottle outside. The vessel is first dipped in the ground coat enamel, the excess of enamel is shaken off, it is put on a three-pointed rack, and dried in the drying-room. After drying the enamel stands in little grains all over the surface of the ware, adhering to the metal on account of the raw clay ground in with it. At this stage every care must be taken, for a scraping even of the finger nail would take off some of the powdered particles of the enamel. This kettle is then put into the muffle of the furnace, and the heat fuses all the little particles together and we have a tight-holding vitreous coating all over the surface of the vessel. This coating is nearly black, due to the oxids of cobalt, nickel and copper which it contains, and shines

with a glass-like luster. The vessel is cooled the ordinary temperature of the furnace-room.

The vessel is again brought to the dipping-room, and here it is dipped into an enamel—this time a white enamel. This goes through the same process as before, except that the beading boy puts a black bead around the upper rim. On account of the dark color of the first coat showing through, this second coat, after it is burned, has a gray appearance, and is called the "gray coat." The vessel is again sent to the dipping-room, and here it is dipped into white enamel, the excess shaken off, and the blue-green enamel is sprayed on the outside.

This spraying process was at one time done by dipping a wire brush into the wet blue-green enamel and the "dipper-girl" shaking it over the surface of the vessel, causing the blue enamel to fall in little speckles all over the white enamel. Lately spraying machines have been put in, which work on the principle of an atomizer. A tank full of the colored enamel stands over the table and the enamel is forced out through a nozzle in a spray by compressed air. The flowing of the enamel is controlled by the foot of the dipper-girl as she holds the vessel to be sprayed in the enamel spray. The vessel is now dried and the coating fused in the muffle-furnace, the result being turqoise-blue spots on a white background. After a handle and lid are put on in the assembling department the vessel is sent to the assorting room. Here all ware is divided into three lots—first, second and job lots. Some of the second and job lots are fit for redipping. They may have some little spots where the original vessel was not properly cleaned and where, on account of this rust or dirt, the enamel did not stick. These spots are filed or are held under a sand-blast until the surface is perfectly clean, and the vessel is dipped with another coat.

There are schemes for saving money in all manufacturing plants, and in the enameling business a large part of the profit comes from the residues. For instance, every bit of enamel is scraped from the tanks and tables; all sweepings from floors are saved, and all the waste water from the various departments is first carried into catch-basins, and every few days these are cleaned and the residue which has settled to the bottom is taken out. The residues from all these sources are again melted with the proper amount of fluxing material and coloring matter, and this dark-colored enamel is used for coating the cheaper ware.

Among other things to be considered in the enameling business is the kind of steel used to make the vessels that are to be enam-

eled. It must be as nearly as possible pure iron, and must be especially low in carbon and sulfur, as these ingredients give off gases upon heating. The following is the analysis of a steel which gave very good satisfaction:

Sulfur	0.045	per cent.
Phosphorus	0.032	"
Silicon	0.010	"
Manganese	0 080	"
Carbon	0.105	"

The grain must be as open as possible, and this fact bars the use of steel which has been cold rolled.

The necessity of having a perfectly clean surface to enamel makes the process of cleaning or "pickling" the ware before enameling very important. In the first place, a lubricant must be used in stamping that is easily removed. For this a sort of soap is used. Then the ware is "pickled"; first in an alkali solution to remove the grease, and then in an acid solution to remove the rust. It is washed between and after these processes in hot water, and after a thorough drying is ready to be enameled.

The foregoing is a brief description of the process of enameling, and the question now comes up, "Is Kansas peculiarly adapted as a place to locate an enameling works?" Our location is geographically the center of the United States and our railroad facilities are excellent. We have near at hand the principal raw materials needed, viz.: Flint, quartz, sand, feldspar and clay; salt and limestone for the manufacture of soda-ash; magnesium sulfate, zinc oxid, and bone-ash, and borax nearer to us than any other enameling plant I know of. The materials for pickling—hydrochloric and sulfuric acids and sodium carbonate—are already being manufactured in the state. However, leaving these all aside, our natural gas and crude pretroleum are so abundant and so ideally adapted both for the production of power and for the melting of the enamel and the burning of the ware that they alone would make it profitable to manufacture enameled ware in Kansas.